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ABSTRACT

A project was designed to evaluate TEAM, a math anxiety reduction program for undergraduate students preparing to be elementary school teachers. The program consisted of two main components: (1) instruction intended to improve problem solving skills using the areas of patterns, probability, measurement, approximation, and estimation; and (2) activities designed to reduce math anxiety and to increase confidence in mathematics. The outcome evaluation for a two-year materials development project consisted of replications of small-scale trials of the materials. Outcome measures included both attitudinal and math concept instruments. Future evaluation research in this or similar programs can concentrate in several areas arising from the development and evaluation of the TEAM materials and course. Areas such as the instructional approach, the integration of testing and teaching, teacher confidence and competence, and interaction between aptitude and treatment need more research. (FG)

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Issues in the Outcome Evaluation of a Math Anxiety Reduction Program For Teacher Education Students

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Abstract

TEAM is a math anxiety reduction program for undergraduate students preparing to be elementary school teachers. The program can be offered as a course preparatory to entering the teacher education sequence, and consists of two main components: 1. instruction designed to improve problem solving skills using the areas of patterns, probability, measurement, and approximation and estimation; 2. activities designed to reduce math anxiety, and increase confidence in mathematics. The outcome evaluation for the two-year materials development project consisted of replications of small-scale trials of the materials and was conducted as part of a WEEA grant. Outcome measures included both attitudinal and math concept instruments.

Issues for evaluators of this or similar programs are in the measurement and design areas. Specifically, issues arise in the selection or development of instruments to evaluate math achievement and problem solving, and the use of open-ended instruments which provide protocols for content analyses. Design issues arise from difficulties in selecting comparison groups and the combination of attitudinal (confidence or anxiety reduction) components within a mathematics course. The latter issue leads to considerations of ATI questions of the combination of components best suited to individuals with different levels of initial math anxiety and math knowledge.

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Issues in the Outcome Evaluation of a Math Anxiety Reduction Program For Teacher Education Students

TEAM is a math anxiety reduction program for undergraduate students preparing to be elementary school teachers (Chapline and Newman, 1980). The program can be offered as a course preparatory to entering the teacher education sequence, and consists of two main conponents: 1. instruction designed to improve problem solving skills using the areas of patterns, probability, measurement, and approximation and estimation; 2. activities designed to reduce math anxiety, and increase confidence in mathematics. The outcome evaluation for the two-year materials development project consisted of replication of small-scale trials of the materials. Outcome measures included both attitudinal and math concept instruments.

The major findings from the outcome evaluation are reported here, along with the strengths and weaknesses of the evaluation and the issues which future evaluations should consider. Formative evaluation of the program has been reported by Chapline (1981).

1. Major findings

The goals of TEAM were to increase mathematics knowledge and understanding, increase confidence in mathematics, reduce math anxiety, increase the perception of math as a female domain, and counteract sex bias in the classroom. Three groups of students participated in TEAM during the two years of the program. During the first year, TEAM I students (N = 44) participated in a one-semester course in which the instruction was carried out by a math educator and a psychologist. During

year 2, the materials were used in two colleges in the fall, with a math educator and a psychologist in one setting and a mathematician and a psychologist in the second setting (TEAM II, N =34). In the spring of the second year the course was taught by a math educator with a "back-up" (non-instructional settings) of a psychologist (TEAM III, N = 29).

Although the evaluation design differed somewhat for each phase of TEAM, the following outcome-related elements were included in the evaluation designs:

A pre-course and post-course administration of three mathematics attitude scales: The Mathematics Anxiety Rating Scale (MARS, Richardson and Suinn, 1972) and the Fennema/Sherman Confidence and Usefulness Scales (1976);

A pre-course and post-course questionnaire;

Comparison group data on attitudes for TEAMS I and III; and

A pre-course and post-course measure of mathematics achievement which was modified after TEAM I.

Two of the attitude measures used, the MARS and the Fennema/Sherman Confidence Scale were positively correlated (r = .37; Chapline, et al., 1979). The MARS is a 98 item instrument which requires the respondent to rate a situation on how frightening it is. The response categories of this five point Likert-type scale range from "not at all to "very much." Situations include dividing a luncheon bill, taking a math test, seeing someone use a slide rule, or meeting your math professor. Our experience is that the MARS requires 30 to 60 minutes to administer, depending on the reading level of the respondents. The first factor in a factor analysis of

the MARS (Rounds and Hendel, 1979; Denker and Tittle, 1980) appears to be a test anxiety factor and accounts for approximately 50% of the variance.

The Fennema/Sherman Confidence Scale does not appear to be as heavily reliant on test anxiety. The twelve items include, among others, "I am sure I can learn mathematics"; "I don't believe I can do advanced mathematics"; "I'm not the type of person who does well in math"; "I'm good in math." These are rated on a five point Likert-type scale ranging from highly agree to highly disagree. The Fennema/Sherman Scales require 15-20 minutes to administer.

Comparison group data were obtained for TEAMS I and III. The comparison groups were mainly students beginning the teacher education sequence. Results on the attitude measures indicate the effect of the use of TEAM materials. Table 1 represents the results for the MARS and the Fennema/Sherman Confidence Usefulness scales. There are consistent and significant decreases in the MARS scores. Decreases for the Comparison III group were not significant. Analysis of covariance for TEAM III and Comparison III groups, using the MARS pretest as the covariate, showed F for the covariate as 62.8 ($p = .000$) and the main effect for groups significant ($F = 13.86$, $p = .0004$). When adjusted for initial status on the MARS scores the post-test difference in MARS scores is significant, with the TEAM III group showing a lower mean score on the measure of math anxiety. Figure 1 shows the (unadjusted) pre-post means for TEAM III and Comparison III groups. The change in the TEAM group's mean does not appear to be due entirely to statistical regression, although the decrease for MARS scores for the Comparison group III probably is (as Tryon [1980] notes, however, a wide

variety of treatments seems to be effective in reducing self-reported test anxiety; perhaps, for math anxiety also, the fact that any treatment is attempted is the critical factor).

Two of the TEAM groups show significant increases pre-post in ratings using the Fennema/Sherman Usefulness and Math Confidence scales. TEAM II does not show significant increases, but the trend is the same direction. The Usefulness scale tended to be significant in the expected direction although the actual mean scores increased less than five points of a possible 60. High usefulness scores were obtained on the pre-course measure, with a resultant ceiling effect with this sample. (The Usefulness scale may be an potential predictor of project drop-outs. In a voluntary workshop-type setting, preliminary data indicate that those students who are anxious and see math as useful may be motivated to remain in programs; for those who do not perceive math as useful, the anxiety produced by the course is not offset and students remove themselves from the situation [Bates, 1981].)

Numerous problems were encountered in assessing the changes in mathematics achievement. The project-developed concepts test was not linked closely to the TEAM content nor to the major objective of teaching students strategies for problem solving: breaking a problem down into smaller units, trying several approaches to solving mathematical problems, and compiling data in an organized manner so that patterns can be identified. On the concepts test which was developed, some students received high pre-course scores and this ceiling effect complicated the analysis of the results. (A post-test only comparison of TEAM I and Comparison I groups showed no difference; for TEAM III, the post-test mean was 5.2 points above the

pre-test mean and this difference was significant.)

The pre- and post-course questionnaires were found to be useful instruments, providing a rich data source. For example, the majority of TEAM students reported that there had been a positive change in their attitudes toward mathematics. Overall, less than 20% reported no change and only 2% (two students) reported attitudes a little more negative. Of considerable interest were the open responses to the question, Do you think your attitudes toward math have changed any this semester? How? Sample responses given by TEAM I students included the following:

1. Oh Yes! In the beginning I didn't realize that I had certain abilities. Now I realize I have the potential.

2. Yes. I don't find it as hard now. Upped my confidence. I was very scared in the beginning because the last math class (in high school) was awful.

3. I do. I am more patient. Before if I didn't understand it, I'd skip it; now I don't give up too easily.

4. I felt very relaxed in the class. I see that you can experiment with math more. It's interesting.

5. Yes. I don't feel as incompetent as I used to. I feel I have a better understanding of math and I don't feel as helpless.

6. Yes, definitely. I previously saw numbers in any form and I blocked them out. Now when I see numbers I take time, I concentrate.

7. I'm a little more comfortable with it. With enough help and work I can do better. I just got a job where math is involved.

2. Strengths and Weaknesses

The question of comparison groups continues to plague the evaluator. Since most of the TEAM participants were a self-selected sample of course registrants, the similarity of any comparison groups is questionable. The waiting list approach was attempted although the N was limited to seven.

Pre-semester measures were mailed to homes and returned by most students on the promise of special workshops for no-credit after the semester. Post-semester measures, however, were not returned although numerous attempts were made to obtain these data; students were no longer interested in the workshops once the semester ended.

In addition to the self-selection problem, comparison classes were difficult to identify which held constant the vocational preference (elementary education) and the number of years of college education. A third problem with control group data in a field setting is the reliance on contacts with other faculty to request the administration of tests to their class and the use of instructional time for data collection.

Another weakness of the evaluation data was the measure of math achievement test that "fit" the objectives. The math concept test used by the project included some of the concepts in the math content. However, it did not focus on nor was the scoring such that it was possible to identify increases in skills in applying problem solving strategies. In this respect, the weakness is similar to that of studies reviewed by Tryon (1980). She summarized her review by pointing to the changes in self-reported test anxiety with almost any treatment; but, "Changing the student's academic performance is another matter" (p. 364). By the end of the project we were clear about the specific type of instrument we needed, but did not have the necessary protocols to construct such a score or measure. That students perceived the attainment of such a goal is clear in some of their comments, cited above.

A major strength of the outcome evaluation design, however, was the replication of the program ideas at different sites, using different instructors, and the different ways in which the psychologist and math educator or mathematician worked together. The two colleges involved are both large urban colleges, part of a university system, with diverse racial and ethnic groups of students.

3. Content Issues Raised by the Outcome Evaluation

There are several issues for future evaluation research arising from the development and evaluation of the TEAM materials and course. These are in the areas of the instructional approach, the integration of testing with teaching, the relationship between the development of confidence and competence in a subject area, the measurement of problem solving skills, and the effect of varying treatment according to initial characteristics of participants.

The instructional approach. The philosophy underlying the teaching strategy used in the TEAM materials is that the confidence and knowledge of the learner are best enhanced by the use of an inductive approach. In this approach, learners are not given the problem solving rules immediately, but arrive at them through generalizing from the solutions to a number of carefully selected and sequenced problems. As indicated by the student logs and open-ended responses, the approach was fruitful in terms of the learners' ability to reconstruct formulas, to feel "comfortable" during examinations, and to feel more confident about math. For some students, however, this is a new approach and their past experience makes them feel that the approach is lengthy and drawn out. It will be important to determine if the approach

is effective for different types of students. (This also relates to the measurement problem discussed below.)

The integration of testing with teaching. It has been suggested that a key variable in assisting learning in mathematics is the frequent use of short quizzes (Begle, 1979). In the TEAM project, tests are used as an opportunity to explore math-related anxiety. While there is some research on the use of tests to increase learning, there is little or no research that was located on frequent uses of tests within a program in which one of the goals is the reduction of anxiety. The number of quizzes needed within programs in which the instructional goals include both competence and reduction of content-related anxiety is another issue for evaluation research.

Confidence and competence. The TEAM materials and course have as their goal increasing mathematics competency and simultaneously building confidence in one's ability to use mathematics, with an accompanying decrease in anxiety about mathematics. The interaction of competence and confidence is one of the as yet untested hypotheses of TEAM. To achieve this goal TEAM materials were designed to present primarily unfamiliar mathematical concepts, so students could perceive clearly their gains in knowledge of mathematics and so that prior negative experiences with particular content areas would not have a major effect. Another issue for evaluation research, then, is the use of unfamiliar mathematical concepts to increase confidence (as opposed to the use of familiar mathematical concepts) in programs such as TEAM. That is, does an imaginative and innovative approach to old skills facilitate the reduction of math anxiety, as well as increasing mathematical problem solving competencies?

The measurement of problem solving skills. Since the inductive approach to teaching mathematical concepts is intended to give the learner a new approach to problem solving in mathematics, the measurement of problem solving skills is critical. Most measurement of problem solving examines problem outcomes or solutions, but does not assess the most important component of the skill, the process by which the student solves the problem. The TEAM project had anticipated working on the measurement problem, but did not have the resources to do so within the time constraints of the project. A serious need to be met is the development of a process measuring "instrument." Careful examination of the effects of the instructional approach, as well as the interdependence of confidence and competence, is not possible without further development of the measurement instrument. Research is needed to define the problem solving "process" in more detail (for these adult learners). Clarification of the initial status in terms of how adult students approach math problems and definitions of the desired process outcome are required. Some work on the measurement process is reported in Malone, et al. (1980) and Schoen and Oehmke (1980), and may serve as a model for projects such as TEAM.

The interaction between aptitude and treatment. TEAM participants were recruited by informing students that the program existed and urging them to enroll. This resulted in a self-selected sample of students who had enrolled for various reasons and who had different levels of mathematical skills and anxieties. It is expected that students with low skill and high anxiety need different treatments than students with high skill and high anxiety or low skill and low anxiety. Systematic identification of these

subgroups is needed in evaluation studies (Tobias and Weissbrod, 1980).

Research on test anxiety also provided further impetus to identify subgroups of students for whom different "treatments" may be appropriate. Tryon's (1980) review of test anxiety identified two components of test anxiety, a worry and an emotionality component. The testing situation (which is a part of math confidence development in the TEAM program) is presently thought to evoke both learned task drives and learned anxiety drives. Some anxiety drives may be task relevant while others are task irrelevant. Performance is facilitated by those learned task drives and learned anxiety drives that are task relevant; task-irrelevant anxiety drives decrease task performance. A high test-anxious person probably attends to both self-relevant and task relevant variables and worries during examinations (or test-like classroom situations). The low test-anxious person is attending mainly to the task. Informal observations of the first TEAM group supports this interpretation in part. An extreme form of such behavior could be found; during discussions in which students prepared for examinations, they were observed carrying out such self-relevant tasks as taking out a mirror and combing their hair. These students were not making task relevant responses, and such behavioral indicators may provide a diagnostic basis other than a self-report inventory such as the MARS for identifying subgroups of students for whom different approaches, or a sequence of approaches, may be required to increase both confidence and performance in mathematics. Tobias and Weissbrod (1980) also suggest the use of indicators other than paper and pencil measures.

In summary, the design of evaluations for math confidence and competence programs such as TEAM face many fundamental questions. Awareness of these questions can assist evaluators to relate new programs to the existing psychological literature on test anxiety and to the developing literature of mathematics competence and confidence.

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Table 1

Pretest-Posttest means, SD's and t for the MARS and F-S Scales:

TEAM I, II, III

MATHEMATICS ANXIETY RATING SCALE*

	Pretest Mean	Posttest Mean	N	t	P
TEAM I	245.3 (SD=64.7)	211.6 (SD=64.6)	44	4.26	.001
TEAM II	249.8 (SD=82.1)	195.8 (SD=66.6)	34	3.13	.003
TEAM III	260.5 (SD=69.1)	198.1 (SD=57.5)	30	6.50	.000
Comparison III	231.1 (SD=63.6)	218.1 (SD=78.2)	41	1.74	.089

FENNEMA-SHERMAN MATH USEFULNESS**

TEAM I	34.8 (SD=6.3)	38.1 (SD=5.7)	44	3.69	.001
TEAM II	48.1 (SD=5.3)	49.3 (SD=6.3)	34	.88	ns
TEAM III	44.3 (SD=7.1)	48.7 (SD=5.9)	30	4.20	.000

FENNEMA-SHERMAN MATH CONFIDENCE**

TEAM I	20.5 (SD=9.6)	26.4 (SD=9.3)	44	5.86	.001
TEAM II	35.9 (SD=11.3)	41.0 (SD=11.5)	34	1.82	ns
TEAM III	30.1 (SD=11.8)	38.5 (SD=10.5)	30	7.60	.000

*Higher scores indicate more math anxiety: 98 items, 1-5 points each.

**Higher scores indicate more math usefulness or confidence: 12 items, 1-5 points each.

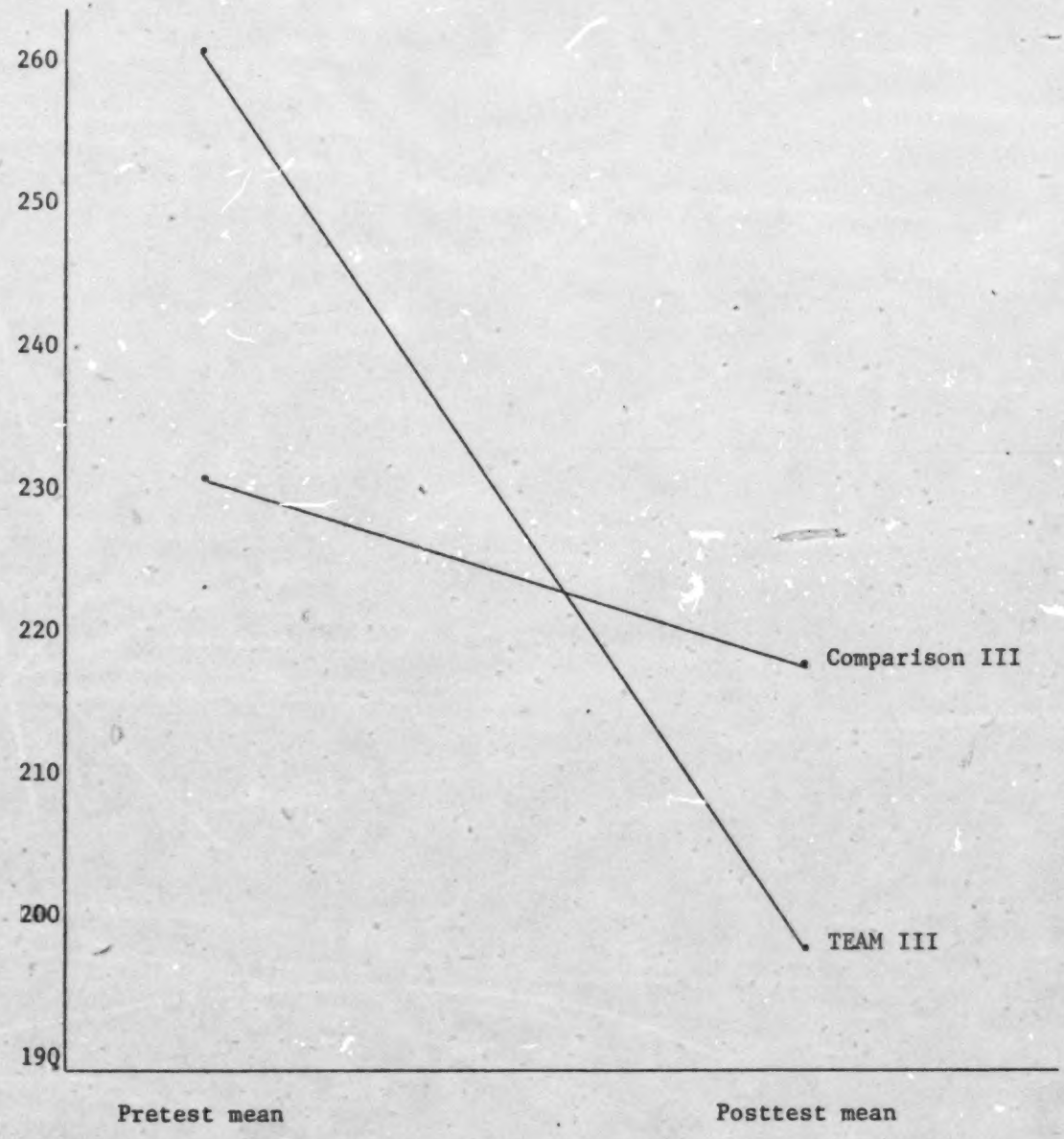

Figure 1. Pre-post MARS scores for the TEAM III and Comparison III groups.